

Article

Evaluation and Countermeasures of the Implementation of the Lake Protection and Governance System in Wuhan City, Middle China

Jingjing Yan ^{1,2}, Wei Shi ^{1,2} and Fei Li ^{1,2,*} 

¹ Research Center for Environment and Health, Zhongnan University of Economics and Law, Wuhan 430073, China; Yanjing@zuel.edu.cn (J.Y.); Shiwei@zuel.edu.cn (W.S.)

² School of Information and Safety Engineering, Zhongnan University of Economics and Law, Wuhan 430073, China

* Correspondence: lifei@zuel.edu.cn

Received: 1 August 2018; Accepted: 12 September 2018; Published: 21 September 2018



Abstract: The protection and management of lakes is closely related to people's quality of life and the rapid development of urban economy, and it is also an important aspect of realizing ecological sustainability. Hubei Province has over 1000 lakes, so the importance of the protection and governance of lakes is self-evident. Since the Lake Protection Regulations of Hubei Province came into being, Hubei Province has achieved the gradual extension and improvement of the system of responsibility for the protection of the lake. In order to understand the development of the system of responsibility for the protection of the lake and to explore the shortcomings in the implementation of the lake management system, this paper takes Wuhan city, capital of Hubei Province, as an example, as the object of research and evaluates the implementation effect of the lake protection mechanism and system after the promulgation of Hubei Province Lake Protection Regulations. According to the evaluation results, since the implementation of the regulations, the formal protection of lakes in Wuhan city has been promoted step by step, and the effect of lake management has also been remarkable. The government attaches great importance to lake protection, and the enthusiasm of government staff participating in this is increasing. However, the evaluation results also reveal some weaknesses of the current system of lake protection and governance, including the protection of lake quality, the perfection of the annual appraisal system and the administrative responsibility system, and the optimization of the lake garbage disposal system. On the basis of the results, this paper puts forward countermeasures and ideas to perfect the mechanism and system of lake protection and management in Wuhan city, in order to provide reference for the lake protection and management in other areas.

Keywords: lake protection; implementation evaluation; Likert Scale Method; countermeasures

1. Introduction

Water resources are an important resource for the rapid development of a city and an important condition for people to survive and develop. Wuhan, as a city that has over 100 lakes, is rich in water resources (Figure 1). According to the Wuhan City Lake Protection Regulations issued by the Wuhan Water Administration, there are 166 lakes in the Wuhan Lake area [1], of which 40 are located in the central city of Wuhan. However, with the rapid development of industrialization, the water pollution in some lakes is serious due to such factors as reclamation of farmland, urban construction and the imperfect construction of the legal system of lakes and the inadequate implementation of the lake protection responsibility mechanism, the lake area is also shrinking [2], especially in Liangzi Lake, one of

the biggest lakes bordering Wuhan city [3]. From 2009 to 2013, Wuhan city's water surface was reduced by a total of 14 square kilometres over a period of five years [4]. With the formal promulgation and implementation of the Hubei Provincial Lakes Protection Regulations (hereinafter referred to as the regulations) in October 2012, Wuhan city has used this as an opportunity to constantly enhance the bases for the protection of lakes and actively create institutional mechanisms, into a new era of lake protection. In the five years since the implementation of the regulations, good progress has been made in the establishment of the lake-head's responsibility mechanism, the protection and management of lakes, the comprehensive treatment of lake water and the ecological environment of the lakes [5]. Over the past five years, a total of 13,600 patrols have been carried out to deal with 143 illegal cases involving the lake and 39 responsible persons. With the changing requirements over time, it is of importance to explore the current advantages and shortcomings during the five years since the enactment of the regulations.

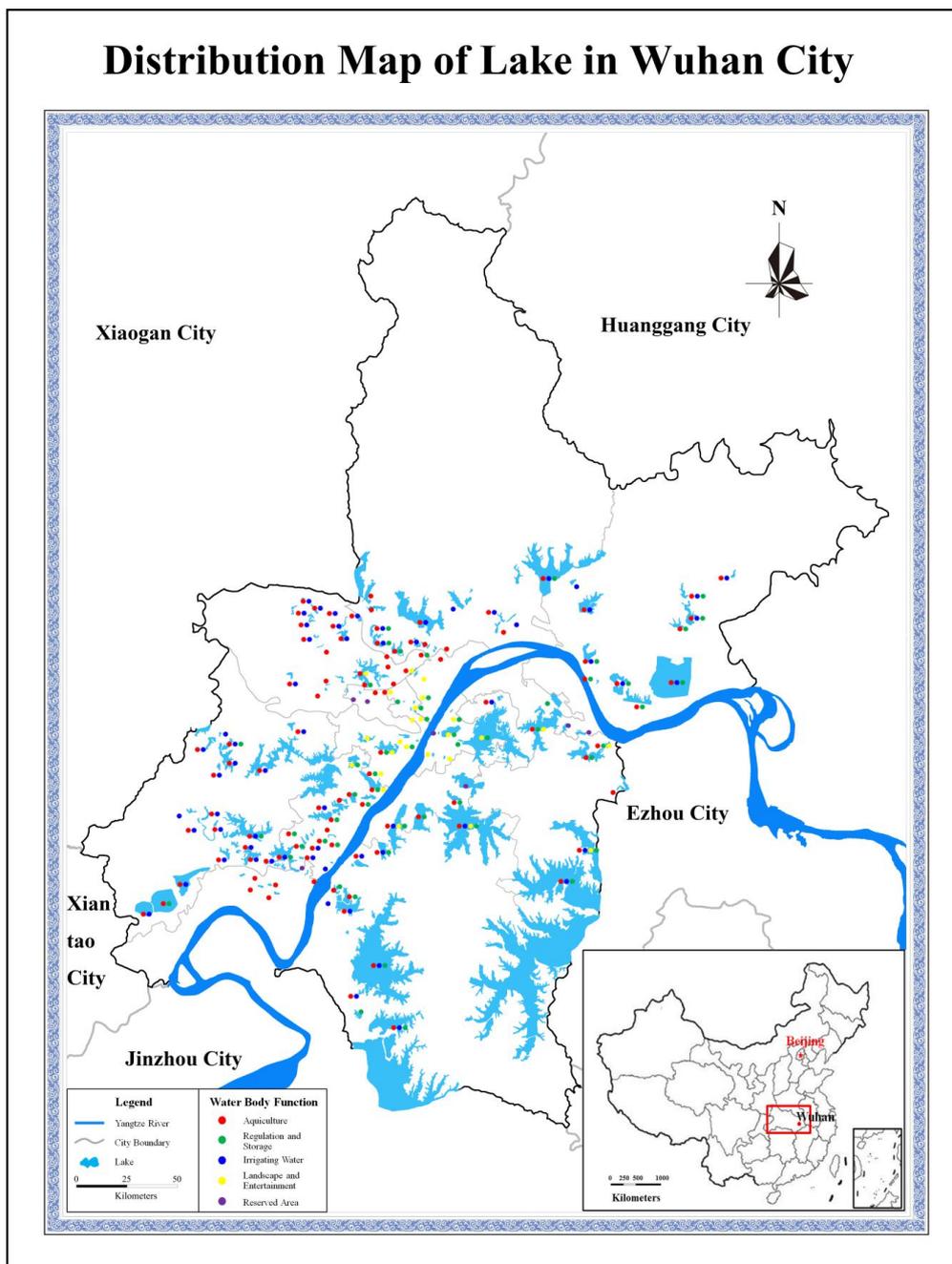


Figure 1. Distribution map of the lakes in the Wuhan city.

Currently, most research that involves lakes is usually focused on water management (quantity and quality) with little on governance [6], and the existing researches only measure governance outcomes and do not offer holistic views of governance practices [7–9]. Also, estimating governance performance is generally complex because in most cases we do not know what and how to measure it [10]. However, the scientific assessment of the protection and governance state of lakes not only identifies shortcomings in the current work but also lays the foundation for the integration of the next steps. Cooley [11] noted that assessment of local people's perceptions on governance performance within their communities can be a strong tool to determine the efficacy of natural resources governance systems, because they possess substantive knowledge about the resource system and areas where they live. Their local knowledge, which is often holistic and spatially specific, could be critical in local governance performance assessment [11]. Unfortunately, water governance performance assessments that explore local people's perceptions are under-documented and rarely get due attention [12]. Therefore, in order to scientifically evaluate implementation of regulation, it is of significance to obtain real perceptions of local people and government staff.

The objectives of this study were: (i) to design a scientific and credible questionnaire based on the government-level in the context of the Likert scale which can reflect respondents' real attitudes towards the implementation of local regulations; (ii) to analyze the state of the implementation of the Wuhan Lake Protection and Governance System based on the results of the questionnaire; (iii) to formulate the targeted countermeasures for improving the found shortcomings of the current Lake Protection and Governance System in Wuhan city.

2. Materials and Methods

2.1. Survey Design and Analysis Methods

Self-compiled questionnaires take a wide range of factors into account including age, gender, type of management, management level, etc. Among them the management department type involves the government, water, environmental protection, agriculture (fishery) industry, construction, forestry and other traditional lake management departments. The management level includes villagers' committees, street offices, township governments, district and county governments, prefectural governments and provincial governments. The design principles and procedures of the questionnaire are strictly followed [13,14]. To ensure the reliability and scientific nature of the questionnaire, the team also organized a small test and audit process [15,16] to ensure the credibility and effectiveness of the findings. In the structure design of the questionnaire, the structure questionnaire is combined with the unstructured questionnaire [17]. Because the structure questionnaire is fixed to give an answer to the problem, the unstructured questionnaire is open-ended and the problem is unified, but in order to give the answer, the use of both fully combines the characteristics of qualitative and quantitative research. The questionnaire is divided into five main areas:

- (1) The basic personal information of the interviewees, including the sex, age, work, unit name, and administrative level of the unit, are used to understand the person who completes the interview, so that data can be collected and analyzed.
- (2) The implementation of the lake management mechanism in Wuhan city, including the regional coordination, the departmental linkage mechanism, the annual appraisal system for lake protection and the administrative responsibility system etc. This paper mainly investigates the degree of satisfaction in the implementation of Lake Protection Management System and whether it has been effectively implemented.
- (3) The implementation of the Lake protection-related regime in Wuhan city, which includes, among others, the implementation of the lake protection investment system, the ecological compensation system, the lake census system, the lake survey system, and the minimum water level system. It is used to understand the implementation of the means and mechanisms for the ecological

protection of lakes with a view to establishing a focus for the improvement of the system which has not yet been perfected.

- (4) The regulations' operational evaluation is intended to understand the overall evaluation of the degree of implementation and operation of the regulations at all levels, as well as its economic and other implications.
- (5) The key aspects of lake protection should be understood in the light of the specific requirements of the regulations, such as the quality of the water, the size of the lake, the number of lakes and so on to understand whether the goal of lake protection is balanced and consistent, to the next need to further strengthen the work of the inspection and to the serious problems of the lake protection priority control.

To assess the implementation of the Lake Protection and Governance System in Wuhan city, the project team has conducted a study on the design of the lake in the context of the Likert Scale Method. The Likert scale is a psychological response scale [18], consisting of a set of attitudinal items, assuming that each item has the same value of attitude and that a score is given on the basis of the respondent's consent and the degree of disagreement. The scores of each item were then evaluated statistically and divided into 5 grades, 7 grades, and 10 grades of the Likert scale, which are often used for questionnaire research. The Likert scale can be used to measure the attitudes of interviewees through the selected answers, which is different from ordinary right and wrong questions. The scale can also find the differences in the degree of respondents' opinions. In addition, the Likert scale is simple and feasible in structure design, and it is widely used in market management, agriculture, environmental protection, medical treatment, biology, education and other fields [19–24]. The content of the implementation of the system of lake management protection in the project group was assigned to the degree of satisfaction. The highest (very satisfied) assignment was 5 points and the lowest satisfaction (very unsatisfactory) was assigned to 0 points. The median value is 1, 2, 3, 4, and the maximum value is changed according to the evaluation item. Based on the study of the maxima, minima, mean, variance and standard deviation of each project, the study group objectively analyzes and evaluates the implementation of the Lake Protection and Governance System in Wuhan city.

2.2. Materials Collection

A total of 163 questionnaires were distributed in the survey, 157 were effectively recovered and the recovery rate was 96.3%. In the course of the questionnaire, stratified sampling was used to divide the overall unit into subtotal (layer) according to its department type and department level, and then carry on the questionnaire from each layer in simple random sampling. The percentage of men and women in the survey was 56.7% and 43.3%, respectively. The sex ratio of the sample was reasonable and the average age of the respondents was 34 years. The proportion of respondents involved in the government, environmental protection, forestry, agriculture and other traditional departments involved in lake management were: 4.5% of the government's work; 83.5% in the water sector; 0.6% in the environmental protection sector and 2.5% in the agriculture (fishery) sector. The construction sector accounted for 1.9% and the forestry sector accounted for 0.6% (Figure 2).

In addition, the proportion of the respondents in the survey was 1.3% of the government units at the provincial level; 6.4% of the local and municipal governments; 82% of the government at the district and county level, and 6% in the township government; street (office) accounted for 1.3% and belonged to the villagers' committee at 2.5% (Figure 3).

In the survey, 62.4% of the units were engaged in law enforcement; 3.2% were engaged in the formulation of relevant policies and laws; 13.4% were engaged in advocacy and 21.00% were engaged in other work (Figure 4). The work involved is: offices, housekeeping, city management, business management, lake management, internal affairs, co-ordination, inspectors, and technical expertise. On the whole, the overwhelming majority of the investigation are law enforcement officers. They all have a clearer understanding of the regulations on lake protection and have a more intuitive feeling for the implementation effect of law enforcement.

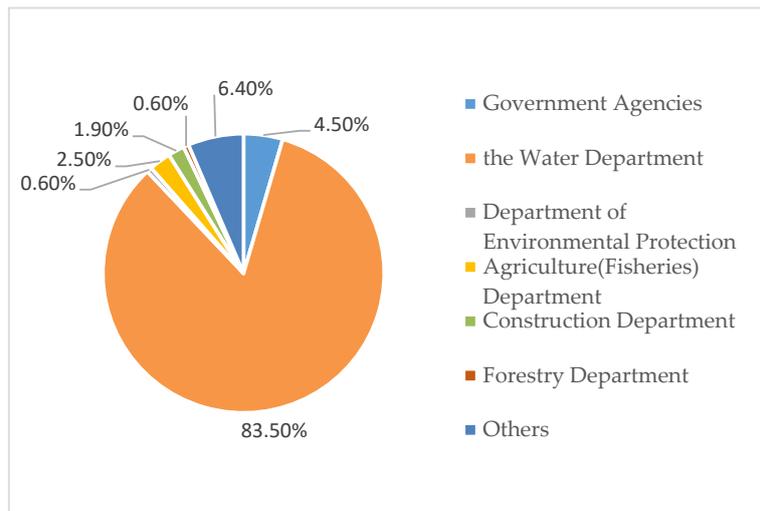


Figure 2. Proportion of departments surveyed.

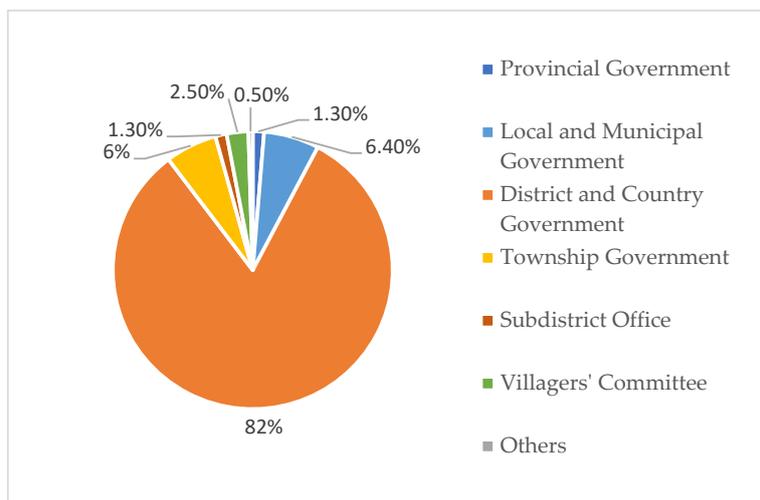


Figure 3. Proportion of unit membership of respondents.

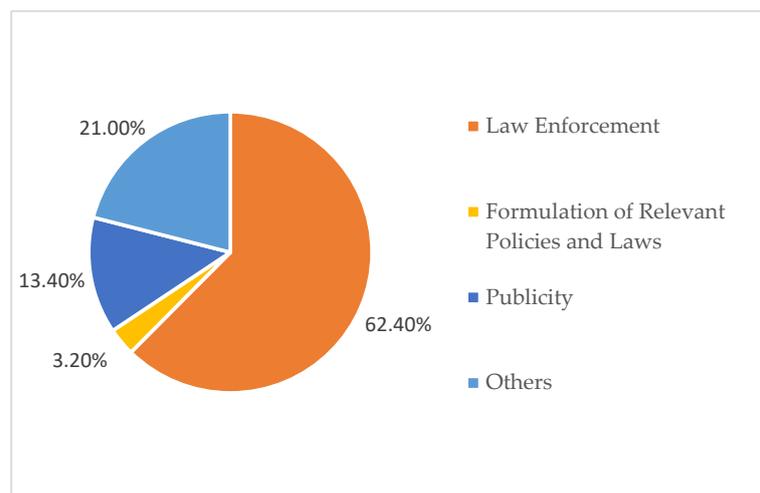


Figure 4. Proportion of work performed by respondents.

3. Results and Discussion

3.1. A Preliminary Statistical Analysis of the Results

3.1.1. The Effect of the Implementation of the Regulations on Lake Protection

Compared with five years ago, the government staff had a significant role in controlling the behaviors of “lake filling” and “lake occupation”. The results of the analysis of the degree variables showed that the interviewees believed that, after the implementation of the regulations, there are immediate effects on such acts as “lake filling” and “lake occupation”, which have been greatly suppressed, and the protection of the lake in Wuhan city has been pushed forward. Most of the interviewees said that the lake management effect is very remarkable. The proportion of people who have participated in the protection of lakes in the government sector is 86%, and the importance attached by the local government to the protection of lakes is quite high (with a full score of 5 and a statistical mean score of 4.69). This is the result of vigorously promoting the reform of the lake protection system, setting up a special lacustrine management body and coordinating organization, and perfecting the lake protection team in Wuhan city in recent years. It also shows that the importance of the Lake Protection work in the government departments is increasing, and the enthusiasm of the government staff to participate in the lake protection work is increasing.

3.1.2. Respondents’ Knowledge of the Current Responsibilities and Priorities of Lake Protection

The regulations of the administrative departments responsible for the protection of lakes in cities, counties and cities of Hubei are relatively specific and clear (with a full score of 5 points and a statistical mean score of 4.54). In the focus of lake protection work, the work of the interviewees in relation to a number of lake protection objectives specified in the regulations is balanced in terms of importance perception and averages around 10%. Among them, it is believed that the focus of the work should be “Protection of lake water quality”, with the highest proportion, reaching 11.8%. “Protecting lake area from decrease”, followed by 11.5%. The third is to protect the number of lakes from decreasing, accounting for 10.5% of the total. These state that in the “Five Guarantees” specified in the regulations, protection of water quality, quantity of water and number of lakes are the three most important tasks that government workers consider most important. Few people think that “Enhance the ability of flood control and drought resistance” is the focus of the lake protection work, which shows that one of the main functions of the lake has not been given high priority by government staff. In addition, 9.2% of the respondents think that lake sustainability needs to be strengthened, which is the largest. “Solving lake protection problems in time” and “Strictly stop the destruction of lakes”, as the next priority, accounts for 8.8%. It shows that these three tasks are short boards that still need to be reinforced in the day-to-day management of lakes (Table 1).

Table 1. Current responsibilities and priorities of lake protection.

Responsibilities and Priorities	Proportion (%)
Protection of lake area from reduction	11.5
Protecting the number of lakes from decreasing	10.5
Protection of lake water quality	11.8
Enhancing lake sustainability	9.2
Implementation of the lake protection responsibility system	8.4
Solving problems in lake protection in time	8.8
Strictly stop the destruction of lakes	8.8
Enhance the ability of flood control and drought resistance	6.5
Strengthening ecological restoration	8.1
Strengthening lake supervision	8.3
Perfecting the system of departmental coordination	8.1

3.2. The Results and Discussion of the Classification and Evaluation of the System of Protection and Management of Lakes

3.2.1. Integrated Assessment of the Effectiveness of the Implementation of the Lake Protection Mechanism

Since the enactment of the *Regulations*, Wuhan city has developed and implemented a series of lake protection mechanisms. This paper designs a comprehensive evaluation of the implementation effect of the lake protection mechanism from three aspects: the regional coordination system of cross-sectoral lake protection and the responsibility system and linkage mechanism of lake protection. The results of its research are shown in Table 2.

Table 2. Evaluation of the effectiveness of the implementation of the Lake Protection Mechanism.

Assignment of Implementation Effect	N	Minima	Maxima	Full Score	Mean Value	Standard Deviation	Variance
The Regional Coordination System of cross-sectoral Lake Protection	154	0	4	5	2.99	0.932	0.869
The Responsibility System	157	0	3		2.56	0.581	0.338
The Linkage Mechanism	157	0	4		3.10	0.955	0.913

As can be seen from Table 2, the effectiveness of regional coordination in the field of cross-sectoral lake protection is at the general level, with an average score of only 2.99 (assigned at a full score of 5) and a standard deviation of 0.932, reflecting the wide divergence of responses to this question; the wide range of views of the interviewees on the regional coordination of lake protection and the scope for further improvement in the regional coordination of lake management protection. It also reflects the apparent problems of Wuhan city's cross-sectoral lake management.

In terms of the rationality of the annual appraisal system and the administrative responsibility system for lake protection, the respondents were assessed as 2.56 (assigned according to a full score of 5), with a standard deviation of 0.581. In comparison with the implementation of the other two systems (the regional coordination system and the linkage mechanism), this is a very low level, which fully demonstrates the general acceptance of the legitimacy of the annual appraisal system and of the administrative responsibility system. Some respondents also said the system was not very reasonable. This aspect shows that the examination mechanism and the system of responsibility bring great pressure to law enforcement, which is considered by a small number of interviewees as a straitjacket on themselves. In the minds of grass-roots law enforcement, this system of administrative responsibility and appraisal system cannot be fully realized in the concrete implementation. On the other hand, it also shows that the lake protection administrators do not attach too much importance to the appraisal mechanism and responsibility system, in other words, such a system does not play a visible role in most of the interviewees. It should be made clear that the annual appraisal system and of the administrative responsibility system are important measures to achieve the objectives of lake protection, and are also the key safeguards to ensure the effectiveness of the regulations. Therefore, the establishment and implementation of the system will enhance the functioning and effectiveness of the enforcement examination mechanism to facilitate the smooth implementation of the regulations. The realization of positive guidance for law enforcement personnel in lakes should be the focus of lake work in the future.

The results of the survey on "the effectiveness of the implementation of the sectoral linkage mechanism and joint meetings system" showed that interviewees believed that the linkage mechanism had been well implemented (with a combined rating of 3.10 on a scale of 5). However, respondents were more divided on the question, with a standard deviation of 0.955; in other words, there were still inconsistencies in the effectiveness of the sectoral linkage mechanism and joint meetings. It also shows that there may still be some problems in the implementation of the system.

3.2.2. An Evaluation of the Effect of the Implementation of the Lake Protection System

In terms of the effectiveness of the implementation of the lake protection investment system in the regulations, the average score was 3.33 (assigned at a maximum of 5 points). The results show that the evaluation of the implementation effect of the lake protection investment system is generally above-average (as shown in Table 3). As a result, the respondents' investment in Lake Protection over the past few years has been relatively satisfactory, indicating that Wuhan city has been working hard over the past few years to protect the lake, and the investment mechanism is becoming more and more perfect. But the standard deviation is slightly higher, indicating that there is still some disagreement among grass-roots managers on the investment mechanism. For the law enforcement at the grass-roots level, investment is the basis for other work. Without sufficient investment, the lake protection work lacks the continuous power, and the lake protection measures and technologies cannot keep up with the need of management.

Table 3. An evaluation of the effect of the implementation of the lake protection system.

Assignment of Implementation Effect	N	Minima	Maxima	Full Score	Mean Value	Standard Deviation	Variance
Investment System	157	0	4	5	3.33	0.737	0.543
Ecological Compensation System	156	0	4		3.26	0.866	0.750
Lake Census System	157	0	3	3	2.58	0.568	0.322
Public Notice System of Lake Exploration	157	0	3		2.67	0.571	0.325
Minimum Water Level System	154	0	3		2.30	0.887	0.786

The ecological compensation system is the key innovation system in the regulations. From the research point of view, the average effect of this system is 3.26 (assigned according to the full score of 5 points). The results show that the evaluation of the implementation effect of the ecological compensation system is better overall. The high standard deviation of 0.866 indicates that there is some disagreement among grass-roots political law enforcement on the implementation of the eco-compensation system, which is related to the status quo of the implementation of ecological compensation in Wuhan city. In some places, the ecological compensation system is better to protect the water quality and the water ecology because the lake protection funds are abundant, and because of the six-lake connection project and the ecological water network project of the East Lake [25], the eco-compensation system becomes more effective. However, as a part of the region of ecological protection, the implementation of this system may not be done very well because of the lack of corresponding compensation. On the whole, the ecological compensation for lake protection in Wuhan city has a system guarantee, as well as practical history and experience. At the same time, the construction of the Lake Protection Project has some support in terms of capital investment, so from the overall point of view, the implementation of this system is still very good.

As to whether the lake census system is reasonable or not, the maximum value of the implementation effect of the lake census system is 3, which is reasonable and can be done. The average value of the assessment was 2.58 (assigned according to the full score of 3 points), indicating that the evaluation of the implementation effect of the lake census system was generally high. This system has been well implemented since the enactment of the regulations. In 2012, in conjunction with the "One Lake One Prospecting" campaign carried out by the Provincial Lakes Bureau, Wuhan city carried out a positioning survey of all the lakes in the city. The functions, geographical location, water quality and quantity of the lakes in the whole city were determined. The information of characteristic elements such as area is arranged in an all-round way, and the specific object and scope of lake protection in Wuhan city are established. It should be said that the implementation of Wuhan lake census system occupies a primary position in the country.

The reasonable evaluation of the public notice system of lake exploration was 2.67 (the maximum value of assignment was 3), which indicated that the system was well implemented. The minimum water level system was reasonable 2.30 (maximum value 3), which shows that the implementation of this system is also relatively good. But the implementation of the lowest water level line system is slightly lower than that of the boundary survey publicity system, which shows that the lowest water level line system may be more difficult to implement than the survey public notice, and it is slightly more difficult to enforce the law. On the other hand, the minimum water level system is designed to protect the ecology of lakes and to prevent the deterioration of aquaculture functions, so it needs more precise and specific measurement methods as the basis. Currently in Wuhan city, lake protection is in the transition period from the protection of form to the protection of ecology. The means and mechanism of lake ecological protection are not perfect.

3.2.3. Assessment of Other Major Lake Protection Systems

In addition to the evaluation of the above lake protection systems, the questionnaire also provides assessments of the implementation of pollution prevention projects; the satisfaction of the garbage disposal system and the implementation of the lake information sharing mechanism (Table 4).

Table 4. Assessment of other major lake protection systems.

Assignment of Implementation Effect	N	Minima	Maxima	Full Score	Mean Value	Standard Deviation	Variance
Pollution Prevention Projects	157	0	4		3.56	0.673	0.453
Garbage Disposal System	157	0	4	4	2.83	1.024	1.049
Lake Information Sharing Mechanism	156	1	4		3.56	0.693	0.481

Pollution prevention projects mainly include the behavior of lake filling, lake encroachment, illegal farming and so on. Among them, the maximum value of the implementation effect of the pollution prevention projects was 4, and the average score was 3.56, which shows that the system's design was reasonable and the implementation effect very good. Limiting the discharge of pollutants, as defined in the regulations, is an important basic system for water quality and ecology protection in the five-guarantee targets of lakes. It is considered by environmental law enforcers to be in good condition, which shows that the law-enforcers have made great achievements in the discharge of lake pollution. In recent years, with the rapid development of Wuhan city's economy, the real estate of Wuhan city encircled the lake [26] and a large number of projects along the lake began one after another, the water quality of the lake in Wuhan city has been kept stable. Restrictions on pollution-control projects and pollution are key initiatives, and it also reflects the government's firm determination to implement the national strategy of ecological civilization and realize the goal of "Beautiful Hubei".

The survey on the garbage disposal system shows that nearly half (45.2%) of the respondents noticed pollutants in the lakes and garbage collection facilities, indicating that lake pollution still exists in some places, mainly living sewage; garbage and feces and other non-point sources of pollution. It also shows that the respondents were satisfied (the maximum value of the value assigned to the waste disposal to meet the need was 4 and the average was 2.83). Overall, compared with the other systems mentioned above, since previous surveys have found that people often observe pollutants such as garbage around lakes, the evaluation of the implementation of such a system is relatively low. Furthermore, respondents' responses to the survey were more divergent, with a standard deviation of 1.024, indicating that some respondents were still quite dissatisfied with the lake garbage collection. The disposal of lake garbage appeared to be one of the priorities of urban lake protection. Since Wuhan city has a large number and wide distribution of lakes, there is still a long way to go to realize the full protection of the lake and to realize the zero pollution.

The statistical results show that the maximum value of implementation effect of the information sharing mechanism is 4, and the average value of the respondents is 3.56, which shows that the

evaluation of the implementation effect of the system is generally high. Lake information sharing is the foundation of the smooth development of lake protection, but it has always been one of the most difficult problems in lake protection.

Prior to the implementation of the regulations, the protection of lakes had been in a state of administration by the various units involved in the lake for a long time. The administrative departments of environmental protection, water conservancy, forestry and agriculture collected lake data according to their work needs. Moreover, the different channels and ways of collecting data in different departments lead to the same kind of data, which greatly limits the efficiency and accuracy of lake protection work, resulting in the lake not being protected scientifically and effectively. Therefore, the regulations, while perfecting the system of the lake protection system, also realize the unified management of lakes and scientific protection through the establishment of Lake Protection Information Sharing Mechanism.

3.2.4. Evaluation of the Operational Effect of the Regulations

As shown in Table 5, the operational evaluation of the regulations was higher, (with a maximum value of 3 and the average of the respondents being 2.67), meaning that most of the systems and implementation were considered to be operational. The operability of the law is a prerequisite for the validity of the law, and the law that cannot be enforced is lifeless. The accumulation of chemical fertilizers and pesticides into lakes through groundwater leads to excessive heavy metal content in lakes and increases health risks. They have done scientific system design and scientific countermeasures to realize the duty of lake protection management and strengthen the law enforcement efficiency of lake protection [27]. The operation of the regulations is high, which will directly enhance the enforcement of the law. According to the results of the survey, this rule is very obvious, and the mean value of the strict execution of the law is 2.47 (the maximum value is 3), which means that the overall evaluation of the implementation of the regulations is generally higher. As a result, based on the operability of the regulations and the high level of enforcement, the survey revealed that the overall assessment of the regulations was high (the maximum was 3 with an average value of 2.42).

Table 5. Evaluation of the operational effect of the regulations.

Assignment of Implementation Effect	N	Minima	Maxima	Full Score	Mean Value	Standard Deviation	Variance
Operability	155	0	3		2.67	0.593	0.352
Overall evaluation	157	0	3		2.42	0.545	0.297
Level of enforcement	157	0	3	3	2.47	0.656	0.430
Impact on economic	156	0	3		2.66	0.638	0.406

The survey revealed that the respondents' assessment of the impact of the regulations on economic development was generally high. (The maximum economic impact has a maximum value of 3, which is considered to have a positive impact, with an average value of 2.66.) It is generally accepted that the protection of the lake environment may hinder economic development, as the lake is a good economic resource to be exploited. With the development of the structural reform of the country's supply side and the guidance of the concept of "Lucid waters and lush mountains are invaluable assets", the public has a new and deeper understanding of the relationship between environmental protection and economic and social development. The lake is a precious natural ecological resource in Wuhan city, and an important strategic resource for the sustainable development of Wuhan's economy and society. The economic function of lake has been paid more and more attention by the government and the people.

4. Main Problems and Countermeasures in the Implementation of Lake Protection and Management System Compared with International Experiences in other Lakes

4.1. Based on the Protection of Lake Source to Ensure that the Lake Water Quality Does not Deterioration

As shown in Table 1, the focus of current lake protection efforts and responsibilities is “Protection of lake water quality”. In recent years, the Wuhan government has been working to improve the protection and restoration of many lake ecosystems in the city and has implemented such policy measures as the “Lake Chief System”. The engineering measures and legal measures, such as “controlling the source and reducing the discharge”, “pollution interception” and “connecting lakes” have generally made good progress, and have demonstrated significance in the field of lake management.

For the prevention and treatment of lake pollution, we should focus on ecological management [28], use from the source, strengthening the source control, and reduce pollution actively. Lake pollution sources have four sources: industrial emission, agricultural production, domestic sewage and lake farming. For the discharge of industrial emission, the relevant government departments should strengthen the industrial emissions of polluting industries around lakes, strictly control emission standards and adopt policies to encourage enterprises to carry out cleaner production; thus, the accumulation and pollution risk of heavy metals in sediment can be reduced at source. The pollution of lakes by agricultural production is mainly caused by field fertilization and pesticides. The accumulation of fertilizers and pesticides into the lakes by groundwater, resulting in excessive levels of heavy metals in lakes and increasing health risks. It is also possible to cause eutrophication of the water body, resulting in blooms, etc. Therefore, it is necessary to implement agricultural management policy, to guide the use of pesticides and fertilizers, to promote accurate fertilization, to implement drip irrigation techniques and so on to avoid overwater pollution of lake water [29]. For the control of the discharge of domestic sewage, we have found, through field surveys, that some residents still live around the lake or even on the small islands in the lake, so it is necessary to collect and dispose of the domestic sewage of this part of the population, and strive to meet the emission targets. The water pollution caused by fish farming on the net, and the large amount of human and animal manure and fertilizer are poured into the lake during the development of aquaculture, thus causing eutrophication; water pollution is caused by the decay of by-products of aquaculture, fish and shrimp waste and dead fish and shrimp [30]. At the same time, the dense net box hinders the natural flow of water body and seriously affects the normal dilution and self-purification function of the water body. The quality of water in lakes such as Honghu Lake and Changhu Lake deteriorates from July to September [31,32]. The relevant departments of the government shall strengthen the management of lake farming, advocate for a rational way of breeding, strictly control the breeding areas, avoid over-breeding and overburden the lakes, and pay attention to the proper dosage of feed, avoid serious contamination of the breeding grounds. Lake Victoria of Africa is a case in point. Lake Victoria has long been affected by unreasonable agricultural production, land use, and wetland damage [33], and various kinds of pollution are discharged directly into the lake, causing the water quality to deteriorate. With the implementation of the Lake Victoria Environmental Management Project (LVEMP) in coastal countries, water quality monitoring networks, operational gauging stations and water quality restoration laboratories have been established [34]. In addition, the management of the lake is closely related to the improvement of the livelihood of the local people, and the pollution at the source is strictly controlled, so that water quality of Lake Victoria is constantly improving. Therefore, the government can learn its management methods, integrate ecological protection with science and technology, social economy and so on, control pollution at source and protect water quality [35].

4.2. Perfecting the Annual Appraisal System and Administrative Responsibility System of Lake Protection

The system of annual appraisal of the responsibility for the lake protection of and the system of administrative responsibility is an important measure to realize the goal of lake protection. It is also the key guarantee to ensure the effectiveness of the regulations. It will further encourage the government departments involved in the lake to fulfil their duty to protect the lakes and promote the

implementation of the principal responsibilities of the various lake protection agencies [36]. However, the investigation shows that the examination mechanism and responsibility system bring great pressure to the law enforcement, and lack of confidence in the successful implementation of the system. Therefore, to improve the function and effect of the law enforcement examination mechanism, we should also pay attention to the proper positive guidance for the law enforcement personnel of the lake, thus fundamentally encouraging the government to carry out the lake protection work. In this respect, the water environment management of American lakes is worthy of reference. Taking the recovery plan of the Great Lakes as an example, the protection of the Great Lakes is jointly supported by the government, civil society organizations and enterprises, and a multi-level management mechanism has been established, including the commission and the special action group. At the same time, the water management organizations involved include the United States Environmental Protection Agency, the United States Department of Agriculture, the Geological Survey, etc. [37]. The water management agencies involved are well-defined, well-connected and well-managed. For the management of the tributaries of the Great Lakes Basin, the appropriate subdivision of authority over the coastal cities, and coordination and liaison groups comprising the United States Secretary of state and the chief executives of the major United States departments are responsible for coordination and assessment to ensure that the responsibilities are in place. With the implementation of the project, the lake water quality environment in the Great Lakes region has improved remarkably [38]. At present, the government should clarify the responsibilities of the various departments in water environmental management, upgrade the lake-head level, define the responsibilities of the lake-masters [39], strengthen the management of cross-basin waters [40], and improve the annual target appraisal method, and carry out the evaluation of target responsibility regularly, carry out the development, and further improve the mechanism of sound responsibility.

4.3. Optimizing Garbage Disposal System and Strengthening Eco-Environmental Education and Publicity

As can be seen from Table 4, the results of the evaluation of the waste disposal system of the lakes by the relevant staff members are not very good. Therefore, a more efficient and feasible system for the disposal of lake garbage in Wuhan remains the focus. Wuhan city has a long way to go to achieve zero pollution in lakes, given the large number of lakes and the wide distribution of lakes [41]. But the optimization of the garbage disposal system is imperative. The corresponding supervision system should be established, and the penalty should be increased so as to reduce the pollution of the water body. Therefore, it is essential to solve the problem by strengthening the construction of high standards [42] and a high-level law enforcement team by adopting the prevention-oriented and comprehensive management method. Public awareness of environmental protection should also be fully mobilized, environmental publicity should be stepped up, supervision and participation of the public and the public media should be strengthened, and the media network should be fully used [43]. The Great Lakes action plan gives much attention to the promotion of education. The plan integrates the promotion of education into society, families and schools, and builds a complete ecological environment protection education system [44]. In addition, the Great Lakes project also launched relevant great lakes conservation courses, which were incorporated into the assessment system as its core curriculum, effectively promoting the spread of the idea of lake protection among the people and improving the national quality [45]. Hubei province is an important province in terms of education, while Wuhan city has a large number of universities, and can set up some related courses such as East Lake, Liangzi Lake, to raise the awareness of lake protection among the whole population.

5. Conclusions

To quantitatively understand the development of the system of responsibility for lake protection and the shortcomings in the implementation of the lake management system, this study took the Chinese Wuhan city as the research object and evaluated its implementation effect of the lake protection mechanism and system after the promulgation of Hubei Province Lake Protection Regulations.

Generally, the survey results of the designed questionnaire based on the Likert Scale Method indicated that the importance of lake protection in government departments and the enthusiasm of government staff to participate in lake protection were increasing, and the effect of the implementation of the regulations on lake protection was effective to some extent. Furthermore, some weaknesses in the current system of the lake protection and governance had been exposed and were mainly included in the fields of the lake quality protection, the annual appraisal and administrative responsibility system of lake protection, and the lake garbage disposal system. Combined with the experience of lake protection at home and abroad, the targeted countermeasures including enhancing the protection of lake source, clarifying the responsibilities of various departments in water environmental management, improving the annual target appraisal method, strengthening the construction of a high-level law enforcement team, mobilizing the public awareness of environmental protection were proposed for the local government and corresponding decision-makers. The present study based on the Likert scale evaluation method could provide the scientific practices for assessing implementation of urban lake protection and governance system and references for sustainable urban lake protection and management in other cities.

Author Contributions: F.L. organized this study and conducted study design, performed the statistical analysis and drafted the manuscript. J.Y. contributed to study design, interpretation of analysis, and revision of the manuscript. W.S. contributed to prepared datasets, performed the statistical analysis and drafted the manuscript. All read and approved the final manuscript.

Funding: This study was financially supported by Humanities and Social Sciences Foundation of Ministry of Education of China (Youth Fund: 17YJCZH081), Nature Science Foundation of Hubei Province (2018CFB722), and Soft Science Project Foundation of Hubei Province (2018ADC144).

Acknowledgments: The authors would like to express their deep gratitude to the teammates including Teng Wang, Zhenzhen Qiu, Jinlong Ma, Yiling Cai, Zairan Liu and Ying Cai.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wu, J.; Xie, H. Research on characteristics of changes of lakes in Wuhan's main urban area. *Procedia Eng.* **2011**, *21*, 395–404. [[CrossRef](#)]
2. Duan, G.; Niu, R. Lake Area Analysis Using Exponential Smoothing Model and Long Time—Series Landsat Images in Wuhan, China. *Sustainability* **2018**, *10*, 149. [[CrossRef](#)]
3. Wang, H.; Yao, J.; Li, Y. An Analysis of Water Environment Factors and an Evaluation of Water Quantity of Liangzi Lake. *Geosci. Environ. Prot.* **2016**, *4*, 44–51. [[CrossRef](#)]
4. Dai, J.; He, M.; Chen, C.; Wang, J. Urban lake evolution and ecological protection of Wuhan city based on GIS. In Proceedings of the 19th International Conference on Geoinformatics, Shanghai, China, 24–26 June 2011; pp. 1–4.
5. Zhou, H. Protecting Lakes according to Law and serving Green Development—Review and Prospect of the Fifth Anniversary of the implementation of the regulations on the Protection of Lakes in Hubei Province. *China Water Resour.* **2017**, *18*, 7–8, 11. (In Chinese)
6. Cooke, P.E.; Darnsawadi, R.; Ratanachai, C. Performance evaluation of lake basin water governance using composite index. *Ecol. Indic.* **2016**, *61*, 466–482. [[CrossRef](#)]
7. Cosgrove, W.J.; Rijsberman, F.R.; Council, W.W. World water vision: Making water everybody's business. *Gestao Integrada De Recursos Hídricos* **2000**, *3*, 350–359.
8. Ballatore, T.J.; Muhandiki, V.S. The case for a World Lake Vision. *Hydrol. Process.* **2002**, *16*, 2079–2089. [[CrossRef](#)]
9. Dunn, G.; Bakker, K. Canadian approaches to assessing water security: An inventory of indicators. *Policy Rep.* **2009**, *27*, 535–551.
10. Bohringer, C.; Jochem, P.E.P. Measuring the immeasurable—A survey of sustainability indices. *Ecol. Econ.* **2007**, *63*, 1–8. [[CrossRef](#)]
11. Cooke, P.E. Local people's perceptions of Lake Basin water governance performance in Thailand. *Ocean Coast. Manag.* **2016**, *120*, 11–28. [[CrossRef](#)]

12. Carr, A. *Grass Roots and Green Tape: Principles and Practices of Environmental Stewardship*; The Federation Press: Sydney, Australia, 2002; Volume 47, pp. 281–284.
13. Arsham, H. Questionnaire Design and Surveys Sampling, SySurvey: The Online Survey Tool. 2002. Available online: <http://home.ubalt.edu/ntsbarsh/Business-stat/stat-data/Surveys.htm> (accessed on 27 August 2018).
14. Rattray, J.; Jones, M.C. Essential elements of questionnaire design and development. *J. Clin. Nurs.* **2010**, *16*, 234–243. [[CrossRef](#)] [[PubMed](#)]
15. Li, C. Design of high confidence questionnaire. *Stat. Decis.* **2009**, *11*, F03. (In Chinese)
16. Li, C.X. Design of high reliability questionnaire. *Stat. Decis.* **2009**, *11*, 191. (In Chinese)
17. Zhang, H.M.; Lin, L.U. Summary on Relative Problems of Questionnaire Survey and Data Analysis in Overseas Tourism Research. *J. Anhui Norm. Univ. (Nat. Sci.)* **2006**, *1*, 88–93.
18. Suarez-Alvarez, J.; Pedrosa, I.; Lozano, L.M.; García-Cueto, E.; Cuesta, M.; Muñiz, J. Using reversed items in Likert scales: A questionable practice. *Psicothema* **2018**, *30*, 149–158. [[PubMed](#)]
19. Perina, D.G.; Marco, C.A.; Smith-Coggins, R.; Kowalenko, T.; Johnston, M.M.; Harvey, A. Well-being among emergency medicine resident physicians: Results from the ABEM longitudinal study of emergency medicine residents. *J. Emerg. Med.* **2018**, *55*, 101–109. [[CrossRef](#)] [[PubMed](#)]
20. Agunloye, O.O.; Ajakaiye, O.O.; Akinola, A.O.; Okagbue, H.I.; Afolabi, A.O. Datasets on factors influencing the urban environmental quality of intra-urban motor parks across density areas of Lagos metropolis. *Data Brief* **2018**, *19*, 2109–2118. [[CrossRef](#)] [[PubMed](#)]
21. Denis-Robichaud, J.; Cerri, R.L.A.; Jones-Bitton, A.; Leblanc, S.J. Dairy producers' attitudes toward reproductive management and performance on canadian dairy farms. *J. Dairy Sci.* **2018**, *101*, 850–860. [[CrossRef](#)] [[PubMed](#)]
22. Rauser, G.; Strielkowski, W.; Streimikiene, D. Smart meters and household electricity consumption: A case study in Ireland. *Energy Environ.* **2018**, *29*, 131–146. [[CrossRef](#)]
23. Butler, Y.G. The role of context in young learners' processes for responding to self-assessment items. *Mod. Lang. J.* **2018**, *102*, 242–261. [[CrossRef](#)]
24. Iscoe, M.; Lord, R.; Schulz, J.; Lee, D.; Cayea, D.; Pahwa, A. Teaching medical students about cost-effectiveness. *Clin. Teach.* **2018**, *15*, 24–28. [[CrossRef](#)] [[PubMed](#)]
25. Liu, H.J.; Yang, Z.Z.; Zuo, H.X.; Deng, W.B.; Zheng, Q. Analysis on Lake Protection and Management of Wuhan. *Shandong Chem. Ind.* **2018**, *47*, 149–150. (In Chinese)
26. Chen, N.; Yang, W. Study on countermeasures of water resources and lake protection in Wuhan. *Yangtze Tribune* **2008**, *5*, 38–42, 75. (In Chinese)
27. Jin, W. A Research on Problems and Countermeasures of Administrative Law Enforcement of Lake Management in Wuhan. Master's Thesis, Central China Normal University, Wuhan, China, June 2016.
28. Li, F.; Huang, J.H.; Zeng, G.M.; Yuan, X.Z.; Li, X.D.; Liang, J.; Wang, X.Y.; Tang, X.J.; Bai, B. Spatial risk assessment and sources identification of heavy metals in surface sediments from the Dongting Lake, Middle China. *J. Geochem. Explor.* **2013**, *132*, 75–83. [[CrossRef](#)]
29. Qin, B. Lake eutrophication: Control countermeasures and recycling exploitation. *Ecol. Eng.* **2009**, *35*, 1569–1573. [[CrossRef](#)]
30. Wu, X.; Deng, K.; Ge, P.; Wang, Y.; Xue, Y. Investigation on the Ecological Environment and Resource Protection Management System of Fuxian Lake. In Proceedings of the 2017 5th International Conference on Mechatronics, Materials, Chemistry and Computer Engineering, Chongqing, China, 24–25 July 2017.
31. Li, F.; Zhang, J.; Liu, C.; Xiao, M.; Wu, Z. Distribution, bioavailability and probabilistic integrated ecological risk assessment of heavy metals in sediments from Honghu Lake, China. *Process Saf. Environ. Prot.* **2018**, *116*, 169–179. [[CrossRef](#)]
32. Li, F.; Qiu, Z.; Zhang, J.; Liu, C.; Cai, Y.; Xiao, M. Spatial distribution and fuzzy health risk assessment of trace elements in surface water from Honghu Lake. *Int. Environ. Res. Public Health* **2017**, *14*, 1011. [[CrossRef](#)] [[PubMed](#)]
33. Muyodi, F.J.; Bugenyi, F.W.B.; Hecky, R.E. Experiences and lessons learned from interventions in the Lake Victoria Basin: The Lake Victoria Environmental Management Project. *Lakes Reserv. Res. Manag.* **2015**, *15*, 77–88. [[CrossRef](#)]
34. Machiwa, P.K. Water quality management and sustainability: The experience of Lake Victoria Environmental Management Project (LVEMP)—Tanzania. *Phys. Chem. Earth* **2003**, *28*, 1111–1115. [[CrossRef](#)]

35. Calas, B.; Martinon, C.A.M. (Eds.) *Shared Waters, Shared Opportunities: Hydropolitics in East Africa*; Mkuki Na Nyota Publishers: Dar es Salaam, Tanzania, 2010.
36. Wang, T. The predicament of Lake Protection System and Mechanism in Hubei Province and the way to crack it: An investigation based on the implementation of the Regulations on the protection of lakes in Hubei Province. *Hubei Univ. Econ. (Humanit. Soc. Sci.)*. **2018**, *7*, 62–65. (In Chinese)
37. Chen, J.M.; Zhao, J.Z.; Liu, G.S.; Kong, X. The Experience and Enlightenment of Integrated River Basin Management for the Great Lakes. *Wetl. Sci.* **2010**, *8*, 189–192. (In Chinese)
38. Dellapenna, J.W. Changing State Water Allocation Laws to Protect the Great Lakes. *Indiana Int. Comp. Law Rev.* **2014**, *24*, 9–51.
39. Huang, W.L. Strengthening Lake Management and Protection has brought historical opportunities. *China Water Resour.* **2018**, *1*, 5. (In Chinese)
40. Zhang, H. On the Problems of Lake Occupation and Legal Countermeasures in the Urbanization Process of Wuhan. Ph.D. Thesis, Wuhan University of Engineering, Wuhan, China, June 2016. (In Chinese)
41. Lv, Z.M.; Chen, H. Thoughts on the Legislation of the Protection of the Yangtze River. *Environ. Prot.* **2016**, *44*, 32–38. (In Chinese)
42. Yuan, F.; Peng, Y.P. The Construction of Ecological Management System of Urban Lakes: A Case Study of Wuhan. *Manag. Sci. Eng.* **2014**, *8*, 51–54.
43. Hu, J.; Li, C.H.; Wang, Y.N. The Current Situation and Suggestions of the Legal System of Lake Protection in China. *Water Resour. Dev. Res.* **2013**, *13*, 15–19.
44. Li, Y.Y.; Liu, J.M.; Huang, X.H.; Shi, L. The experience of the action plan for restoring North America's Great Lakes and the suggestions for the eco-environmental protection of lakes in China. *World Environ.* **2018**, *2*, 33–36.
45. Pate, J.A.; McKinnon, E.E. A citizen engagement approach to water advocacy: Experiences from “eXXpedition Great Lakes”. *Mar. Aff. Natl. Mar. Found. India* **2016**, *12*, 99–108. [[CrossRef](#)]



© 2018 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).